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RELEASE OF RADIOACTIVE WASTES TO GROUND

By: J.W. Healy

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RELEASE OF RADIOACTIVE WASTES TO GROUND

Recent advances in the information available from studies in Geology,
Hydrology, and Soil Science, conducted by the Biophysics Section have
indicated a need for a revision in the waste disposal policies in the
Separations areas. Fortunately, the present data indicate that past
policies may have been conservative, and that some increase in the
levels cribbed may be allowed.

This report is intended to review some of the data available from pres-
ent disposal practices and to indicate in a qualitative manner the de-
velopments in these various sciences that prompt the review. Also
discussed are those regions where additional data are needed before
major changes in the policy may be permitted.

I. SUMMARY

A brief resume' of the data available on the present disposal systems
in the Separations areas indicates that the regions of ground water
presently contaminated contain ruthenium and have resulted from the
operation of reverse wells close to the water table or from the dis-
posal of high salt content wastes in a crib or sump.

The maximum permissible concentrations permitted in the Columbia River
from these fission products are indicated. A discussion of the soil
adsorption by ion exchange indicates that the adsorption is adversely
affected by high salt contents in the waste, and varies with the ionic

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species and concentration of the radioisotope. The retention of ad-
sorbed isotopes is expected to be essentially for an indefinite per-
iod if the material is not removed by prolonged flushing with non-
contaminated water or, more importantly, by complexing agents. The
possibility of the movement of isotopes by movement of small particles
through the soil is advanced. The time of movement of ground water
from the Separations areas to the river is estimated as varying from
50 years to 1500 years, depending upon the initial location of the
water. On this basis, the contamination of the ground water with iso-
topes with half-lives up to 3 years is permitted. Concern is express-
ed on the possibility of building a ground water plateau under the
Separations areas if the disposal of 5,000,000 to 15,000,000 gallons
of water per day is carried out for long periods of time. This is
postulated as possibly increasing the ground water gradient to the
river and thus accelerating the movement. Careful audits of the com-
position of wastes to the ground are needed to permit useful ground
studies and assurance of safe operation.

II. PAST AND PRESENT DISPOSAL PRACTICES

Some experience has been obtained with the disposal of radioactive
wastes to the ground at Hanford.[1,2] An extensive geology-hydrology in-
vestigation conducted since 1947 has permitted a reasonable estimate
of the movement of the radioactive materials associated with these
wastes. Unfortunately, the knowledge of what has been disposed of is
not sufficiently extensive to permit detailed conclusions or extrapo-
lations to other situations. A brief review of the major waste streams

released to the ground is worthwhile, however, as an orientation in problems of further disposal.

1. First Cycle Wastes

The first cycle wastes have been stored in waste tanks with evaporation and cribbing of the condensate in order to release tank storage space. The evaporators have completed a first pass on all except approximately 4.5 million gallons now in the tank farms.

No data are available on the evaporated first cycle wastes now in storage. Analyses of the supernate from the non-concentrated first cycle wastes have been reported by Burns, and are summarized below in Table 1. [3]

TABLE 1

First Cycle Supernates

Element	Average $\mu c/cc$	Range $\mu c/cc$	109-TX $\mu c/cc$
Gross beta emitters	0.18	0.12 - 0.42	2.91
Sr	0.006	0.0001 - 0.022	0.00087
Cs	0.14	0.10 - 0.17	0.27
Ru	0.032	--	0.34
RE + Y + Ce	0.029	--	0.0085
Ce	0.02	0.007 - 0.05	0.0035
Nb	0.014	--	0.34
Zr	$< 10^{-3}$	--	1.2
Te	1.8×10^{-5}	--	8×10^{-5}

The 109-TX tank was listed separately since it was filled in August 1949, as compared to dates of August 1945 to October 1947 for the other 12 tanks sampled. The salt content of these supernates from

the same analyses indicated NO_3^- - 1.5M, Na^+ - 2.2M, $PO_4^=$ - 0.21M,

$SO_4^=$ - 0.05M, and F^- - 0.2M with a pH of 9.5.

About 4,500,000 gallons of this waste which have not been evaporated

will be disposed of to the ground in such a fashion that the total in-

flow per square foot of ground will not exceed 150 gallons. This will

mean that essentially all of the liquid will be retained above the

water table as water of retention in the soil. Even if a portion does

reach the water table at a future date, the retention by soil adsorp-

tion should be great enough to remove nearly all of the fission prod-

ucts even with this high salt content.

2. Cribbed Wastes

A summary of the amounts cribbed at major disposal sites up to July

1, 1952 is given in Tables 2 and 3, with the best dates now available

for the use of each system.[5,6,7,8,9,10,14] The TBP and Redox cribs

are not included in this tabulation because of the relatively short

period that they have operated.

The values for curies of fission products are for the amount present

at time of release to the system, and do not include the decay that has

occurred since addition because of the lack of adequate data on the

composition. This estimate of the fission products is undoubtedly low

since counting rate corrections were made only for the counter geometry,

and some of the results were obtained with a 25 mg/cm^2 gold or 20 mg/cm^2

aluminum absorber between the sample and the counter. There is some in-

dication that these values may be low by about a factor of four.

An analysis of the 110-111-112T cascade used for a combination of cell

TABLE 2
MAJOR GROUND DISPOSAL SITES - 200-WEST AREA

Disposal Site	Source of Wastes	Settling	Estimated Volume - liters	Est. Pu-grams	Est. F.P.-curies	Max.Ground Water Content $\mu c/cc$
231-W-150 Reverse Well	231 Process 2/1/45-6/1/45	Sump tank	1.0×10^6	50	--	--
231-#1 and #2 cribs	231 Process 6/1/45-2/11/47	Sump tank	30.8×10^6	340	--	---
231-Trenches	231 Process 2/11/47 - date	Sump	40×10^6	300	--	--
234-5 #1 and #2 cribs	234-5 Process 6/49 - date	Sump tank	34×10^6	188*	--	--
241T-361A Reverse Well	5-6 Startup-8/15/46 224 Startup-8/15/46	361 Tank 361 Tank	11.3×10^6	3350*	2800*	1.6×10^{-6}
241T #1 and #2 cribs	224 11/4/46-5/52	201 Tank or 204-203-202 cascade	29×10^6	3720*	1500*	1×10^{-6}
361T-#1 and #2 cribs	224 8/15/46- 10/11/46 5-6 8/15/46- 10/24/47	361 Tank and reverse well. 361 Tank to 10/17/46 none 10/24/47-6/51	45×10^6	117* 275	2800* 15000	--
241T - #3 crib and tile field	2nd cycle 4/48 - date	110-111-112 T cascade	32×10^6	42	700	See #1 and #2 cribs

* Indicates amount to settling tank.

TABLE 3
MAJOR GROUND DISPOSAL SITES - 200-EAST AREA

Disposal Site	Source of Wastes	Settling	Estimated Volume - liters	Est. Pu-grams	Est. F.P.-curies	Max.Ground Water Content $\mu c/cc$
241-B-361 Reverse Well	5-6 4/1/45 - 9/2/47 224 4/1/45 - 9/24/46	361B Tank 361B Tank	30.6×10^6	4275*	3800*	10^{-5}
5-6 crib and tile field	5-6 8/12/48 - 7/4/51	none	36×10^6	174	7800	--
241B #1 and #2 cribs	224 10/2/46 - 10/48 10/48-date	201 Tank 204-203-202 cascade	40×10^6	4230*	5100*	--
241B #3 crib and tile field	2nd 3/48-date cycle 7/1/51-date	3 tank cascade	23×10^6	24	630	4×10^{-6}

*Indicates amount to settling tank.

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drainage, 2nd cycle, and 224 wastes has been made by Honstead in a study designed to indicate the need for a sampler on this stream.[4] He indicated a mean concentration of waste to the crib of $0.07 \mu c/cc$ during the period August to November of 1952. The estimated time of holdup in the cascade tanks, by somewhat inexact methods, was on the order of 20 days with some indication that there was mixing only in the top few inches of the tank. Analyses of the 112-T tank solution, which is as close to the crib as present sampling facilities will permit, have indicated that about 40-50% of the beta emitters are ruthenium, about 2-8% Sr, about 4-8% cerium or rare earths, and 40-50% cesium.[5]

The ground water has been contaminated in the vicinity of the two reverse wells used for 224 and 5-6 wastes and near the 241-T cribs and the 241-B #3 cribs. Tables 2 and 3 indicate the maximum values obtained at these sources. Analyses of the isotopes indicate that the beta emitters are almost all ruthenium isotopes. It appears to be significant that the ground water around the 5-6 cribs, which have received low salt wastes, is still not contaminated in spite of the large volumes of water and relatively large quantities of fission products sent to these cribs.

3. Large Volume Wastes

In addition to the radioactive process wastes to the ground, there are large quantities of presumably clean water arising from steam condensates and cooling jackets that are placed into large open ponds or swamps from which the water seeps into the ground. Estimates of the rate of disposal are given in outline form in Table 4.

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TABLE 4

Large Volume Wastes

Location	Dates	Estimated Volume
B-Swamp	1945 - May 1950 May 1950 - March 1952 Total to April 1953	1,000,000 gal/da 2,000,000-2,500,000 gal/da 5×10^9 gal.
Powerhouse-200E	1945 - date Total to April 1953	150,000 gal/day 4.5×10^8 gal.
T-Swamp	1945 - July 1050 July 1950 - Jan.1952 Jan.1952 - April 1953 Total to April 1953	1,500,000 gal/da 2,000,000-2,500,000 gal/da 1,500,000 gal/da 6.25×10^9 gal.
U-Swamp	1945 - July 1949 July 1949 - Aug. 1952 Aug.1952 - Jan. 1953 Jan.1953 - April 1953 Total to April 1953	350,000 gal/da 500,000-600,000 gal/da 3,300,000 gal/da * 5,000,000 gal/da 2×10^9 gal.
Redox Swamp	Oct.1951 - Mar.1952 Mar.1952 - Aug.1952 Aug.1952 - Feb. 1953 Feb.1953 - April 1953 Total to April 1953	10,000,000 gal/mo. 1,000,000 gal/da 3,000,000 gal/da 2,000,000 gal/da 7.3×10^8 gal.

*About 200,000 gallons per day are now overflowing to the Redox swamp.

In theory, these wastes are checked before disposal by holdup in a retention basin and sampling. In 1952, the Redox swamp received contaminated water resulting from a failure of coils in waste evaporators with fission product concentrations of 10^{-5} to 10^{-3} $\mu c/cc$ and Pu concentrations of 10^{-8} to 10^{-7} $\mu c/cc$ resulting.[15] Plans are now being made to dispose of these wastes underground to eliminate contamination spread by windblown silt or migratory waterfowl.

When Purex is started, an additional 10,000,000 gallons per day will be

placed in a swamp just south of the present B Plant swamp. At this
time, the disposal to the T Plant swamp and U Plant swamp should de-
crease.

III. FACTORS IN GROUND DISPOSAL

The Radiological Sciences Department is interested in seeing that waste
disposal techniques are as liberal as possible without risking future
difficulties with release of long-lived isotopes to the environs at a
spot where harm may arise to humans or other life-forms. The past work
of Earth Sciences, particularly on the movement of ground water and the
adsorption of the radioisotopes on soils, has given increased confidence
in general techniques of ground disposal. As a result of this work, a
more realistic estimate of the amounts of isotopes which may be discharg-
ed under specified conditions has been obtained. The present policy con-
sists of reviewing each source of wastes to be cribbed and specifying the
conditions which should prevail. It is felt that this policy is superior
to simply designating a limit which all wastes must meet before cribbing
because of the importance of the variables of location, salt content, and
volume.

Unfortunately, this work has not progressed to the point where large in-
creases of radioisotopes discharged to the ground can be permitted. The
present purpose is to review the current knowledge of the factors influenc-
ing discharge in order to indicate the areas of uncertainty as well as the
information that now permits further cribbing.

This policy, incidentally, is a departure from original viewpoints that
the ground disposal of wastes is a temporary measure to be discontinued

as soon as process developments permit. The present policy assumes
that the Atomic Energy Commission is prepared to hold the Separations
areas and environs for a considerable period of time. The commitment
on the Separations areas has, in fact, been made on the basis of wastes
now stored or released. It is now assumed that, if necessary, this
area may be expanded somewhat, if the ground water is contaminated.

On this policy, the chief concern is probably the contamination of the
Columbia or Yakima Rivers by ground water flowing from the Separations
areas to the public streams. Thus, the main factors to be considered are:

(1) The adsorption of the radioactive material in the soil beneath
the disposal points

(2) The retention of this material by the soil

(3) The time of movement of the ground water (and associated radio-
active materials) from the Separations areas to the rivers

(4) The adsorption in the water table gravels, and

(5) The maximum permissible concentration of the radioisotopes in
the rivers.

1. Allowable Concentration in River

The allowable river concentrations are guided in part by the AEC policy
on waste disposal, which is still somewhat tentative although the major
features of the present proposals appear to be reasonably well accepted.
These policies state, in essence, that the concentration of isotopes at
any point of use of the medium into which they are discharged should be
less than 10% of the values applied to personnel engaged in radiation
work. Thus, the exposure would correspond to 30 mrem per week. This

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reduction is intended to protect the general populace who do not
have the advantages of routine medical examination, recorded con-
trol of exposure, and other services provided to the general radia-
tion workers.

Under present thinking, this exposure may be averaged over a one year
period, providing that the maximum 24-hour rate does not exceed twenty
times the average permissible for one year, and that the maximum con-
centration averaged over one liter does not exceed one hundred times
the permissible average.[11] An estimate of the average concentration
in the river that could be tolerated if this were the only source con-
tributing may be obtained from the maximum permissible concentrations
for drinking water listed in the National Bureau of Standards Handbook
#52.[12] Some of the pertinent values, adjusted to the 10% for the
general populace are given in Table 5.

TABLE 5

Permissible Concentrations in Drinking Water
General Populace

Isotope	Half-life	Maximum Permissible Concentration $\mu c/cc$
Sr^{89}	54 d	7×10^{-6}
$Sr^{90} + Y^{90}$	19.9 y	8×10^{-8}
Y^{91}	57 d	0.02
Nb^{95}	35 d	4×10^{-4}
$Ru^{106} + Rh^{106}$	1 y	0.01
Te^{127}	115 d	3×10^{-3}
Te^{129}	33 d	10^{-3}
$Cs^{137} + Ba^{137}$	37 y	1.5×10^{-4}
$Ce^{144} + Pr^{144}$	290 d	4×10^{-3}
Pm^{147}	2.6 y	0.1
Sm^{151}	122 y	0.02

It should be emphasized that these concentrations are not independent of one another but are additive. Present policy permits adding of bone seekers separately from muscle seekers, etc.[11,12] When these concentrations are applied to the Columbia River, an additional decrease to 10% of the values given should be made since the river is now used for the disposal of reactor cooling water. This source now contaminates the river to about 5-10% of the MPC, with higher values than this possible with increased power levels of the reactors. Until a different method of disposal of cooling water is found, it must be assumed that it will continue.

Of these isotopes, the ones of chief concern will be Sr^{90} and Cs^{137} because of their long half-lives and high yield in fission. Of minor concern will be Rb^{87}, Tc^{99}, I^{129}, and Cs^{135} which occur in low fission yield or have such long half-lives that the number of curies formed is small.

If ground water is to be used directly, the concentrations listed in Table 5 may be used directly.

If the ground water is released to the river uniformly through the year, an estimate of the ground water concentration permissible before reaching the river can be made. It is doubtful that as much is contributed during high water because of backup of the water table near the river during high water. The rate of dilution after discharge into the relatively slow moving water around the wetted periphery of the river is also questionable with the possibility of considerable channeling causing local variations. R. E. Brown has estimated that a maximum of about

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1/5000 of the flow of the Columbia River is contributed by ground

water entering as it flows through the Hanford area. This estimate

would indicate a possibility of ground water contamination of 4×10^{-4}

μc/cc of Sr^{90} and 0.7 μc/cc of Cs^{137}.

2. Adsorption at Disposal Point

Many of the radioisotopes, particularly at the low concentrations of

the element found in wastes, are adsorbed by the soil through which

the wastes pass. There appears to be general agreement that the bulk

of the material is removed by ion exchange, particularly by the mont-

morillinite clays that make up 1-10% of the soil, depending upon the

portion of the soil profile. This process has prevented the contamina-

tion of the ground water at most of the disposal sites that have been

used in the past.

The ion exchange process is affected by many variables, but the ones

of most importance in soil work, other than the nature of the ion, appear

to be the concentration of the ion in question, the salt content of the liq-

uor, and perhaps the pH of the solution. The quantitative aspects of

this portion of the problem are now under investigation by Earth Sciences.

Results available from studies with strontium and cesium indicate that,

as would be expected, a greater percentage is adsorbed by a given soil

column from a dilute solution. The total amount of material taken up

per gram of soil, however, is greater for the more concentrated solution

as would be predicted by the mass action law. This indicates that wastes

disposed of to the ground should not be diluted since a greater amount

of the radioactive isotopes will be held in the soil from the non-diluted

solution. This may be visualized by considering the difference in

concentration between the solution and the soil as the "driving force"

for adsorption (as long as the ion exchange points in the soil have

not been saturated by non-replaceable ions). As the more concentrated

solution enters the soil, the higher concentration causes more of the

isotopes to be held by the soil. The final cleanup is then done as

the partially cleaned effluent passes through the next increment of

soil.

This does not permit license in depending upon the soil for the disposal

of large quantities of isotopes since the soil will become saturated and

pass the solution with no further adsorption. One of the fallacies of

setting a definite limit in terms of concentration of isotopes in waste

to be cribbed is illustrated by this aspect since the temptation to di-

lute wastes to reach this limit is always strong. In many cases, it may

be preferable to dispose of the undiluted wastes to permit more efficient

use of the ground column.

The degree of adsorption is not the same for all isotopes. Plutonium

and strontium, fortunately, are strongly held (at least in the valence

states normally encountered in wastes). Ruthenium appears to be the most

mobile and is found at the greatest distances from the disposal point.

Cesium is intermediate in mobility, as shown by examinations of soil

samples, from the vicinity of the cribs and by laboratory studies. This

makes cesium one of the more troublesome isotopes because of its high

fission yield and the 37 year half-life of Cs^{137}.

The effect of pH on the adsorption from salt free solutions varies with

the particular isotope. In general, adsorption is poor from strongly acid solutions, and strongly basic solutions give poor adsorption and tend to quickly plug the soil at the point of entry. The best pH for disposal appears to be about neutral with the actual pH near this point not too critical.

Even more important than the radioisotope concentration is the concentration of inert salts. These salts compete with the radioisotopes for the ion exchange points in the soil and thus inhibit the adsorption. This is illustrated in the field studies by the presence of radioisotopes in the ground water near the 2nd cycle cribs in both Separations areas, while the ground water around the 5-6 cribs is not yet detectably contaminated. Laboratory studies on strontium and cesium with sodium nitrate as the added salt indicate a strong inhibition (about 10-20% as much adsorbed in a 10% $NaNO_3$ solution as in distilled water) of adsorption caused by this material. Plutonium adsorption is not greatly affected by sodium or strontium nitrate but aluminum nitrate in a slightly acid solution (pH4) strongly decreases the adsorption. Other salts will undoubtedly have different effects and must be evaluated separately.

The retention on gravels in the water table should be capable of analysis from the same information obtained in the study of retention at the disposal point. This may well become an important factor because of the large distances (20,000-80,000 feet) which the water must travel though these gravels as compared to the distance between the ground surface and the water table (200 feet) at the crib site.

One possibility that is little understood at the moment is the travel of of small, perhaps colloidal, particles containing significant quantities

of adsorbed radioisotopes. These particles may be present in the wastes or may be small clay particles which adsorb isotopes and are then washed through the gravels by the motion of the water. Although the probability of moving any distance appears to be low because of the efficient filtering action of the soils, there may be such a large number that the product of the probability and the number is significant. Although such a phenomenon has not been specifically noted, there is some indication that sporadic positive results are obtained from water in wells near the disposal points but otherwise not contaminated. The frequency appears to be significantly higher than in wells at remote locations, and may be due to this cause.

The quantitative data on these effects are not yet great enough to permit confident appraisals of the probable ion exchange from a high salt waste. The program of Earth Sciences includes numerous studies on the effects of salts on the ion exchange of each isotope in relation to the total ion exchange capacity of the soil so that a measurement of the total ion exchange capacity of any soil may permit confident extrapolation as to the amount of adsorption expected.

3. Retention on Soil

It is believed that the radioisotopes adsorbed on the soil will be retained essentially indefinitely as long as no additional liquids are passed through the soil. In this climate of low rainfall, this means that once addition of wastes ceases, the radioactive isotopes will be held in position with only minor movements over the years. Additional work is planned to obtain definite data on this point.

In a crib where additional fluids are added, there will be continual removal from the soil and readsorption at a lower level. Thus, if low-level wastes are placed in a crib formerly used for high-level wastes, there will be washing of the isotopes to a lower level. Of particular importance in this connection is the possibility of disposing of agents which will complex the ions already adsorbed and bind them into a chemical state where further adsorption is negligible. Specific instances of this are not known, although it may help to account for the passage of ruthenium to the ground water in the 2nd cycle cribs.

Another type of retention that has been used recently is the saturation of the soil with moisture. Since most of the soils beneath the area have a moisture content far below their specific retention, it is possible to add only enough water to bring the moisture content up to the specific retention. In this case, all of the solution is retained above the water table for an indefinite period of years which is believed to be very long.

4. Time of Movement of Ground Water

In the early days of the Hanford operations, it was thought that the flow of water from beneath the Separations areas to the Columbia River would require about 10-50 years. One of the results of the hydrology studies in recent years has been to give a reasonable value for the rate of movement of this water, although a simple value for the time of movement in any direction cannot be given because of the complexities to be discussed.

Studies in the 300 Area on the rate of movement of the discrete zone

of uranium contamination caused by the disposal ponds has given a

value for the gravel permeabilities in this region. This value has

been compared with the estimated rate of movement of the contaminated

zone from the reverse well used in the 200-East Area. These results

have indicated a probable rate of movement of about 100 feet per month

with a head drop of 8 feet in 1000 feet. This value is reasonably

good for the area south and east of the Separations areas, but the lat-

er gravels north of the Separations areas, particularly in the valley

on the south side of Gable Mountain and near the Columbia River, prob-

ably have a permeability several times that indicated by these measure-

ments.

The water table before plant operations was inferred to have a slope of

about 65 feet in a distance of 75,000 to 80,000 feet toward the west,

and a slope of about 40 feet in a distance of 30,000 feet toward the

north.[13] Although the slope is smaller close to the river, an appli-

cation of the flow rate found to the average slope would indicate a time

of 600 to 700 years for travel to the east, and 150 to 160 years for

travel to the north with no allowance made for the increased permeabil-

ity of the gravels in the latter case.

The disposal of large quantities of water in the T Plant, B Plant,

U Plant, and Redox swamps, has changed the water table picture quite

severely. Instead of uniform, sloping contours from Cold Creek Valley

to the river, definite "mounds" or hills of water have been built up on

the surface of the water table due to the inability of the gravels to

conduct all of the water away from the disposal site. This causes a

definite change in the gradient between the areas and the river.

Figure 1 shows the latest ground water map and illustrates the

mounds from the T Plant swamp, the B Plant swamp, and the Redox

swamp. The latter mound is still being formed and is expected to

become still higher. R.E. Brown has estimated the time for the

contaminated water from the reverse well in 200-West Area to reach

the Columbia River as 1500 to 2000 years. This long time interval

is due to the present fortuitous location of the ground water mounds

since these artificial barriers force this particular water to pur-

sue a course south of the 200-East Area mound and then east to the

river. The movement is slow due to the long distances of flat slope

caused by these mounds. Rough estimates of the time for water to move

from the east edge of the present 200-East mound to the river, and

from the north edge of the T Plant mound north to the river, give 90 to

100 years and 140 to 160 years, respectively, without consideration

of the increased gravel permeabilities in this direction. A more re-

alistic value would probably be on the order of 50 to 100 years.

The present situation appears to be well under control with all of

the active disposal points between the two mounds which tend to im-

mobilize the water between them. As time passes, however, more water

is being put into the ground. With the start of Purex, about 10,000,000

gallons per day will be disposed of to the south of the present B Plant

swamp. This will enlarge this mound and may, in time, force a northward

movement of the water between the two mounds. This is not desirable be-

cause of the permeable gravels and relatively short distance to the river

in this direction.

As more and more water is added, the general level of the water table
under the Separations areas will be raised with the two mounds essen-
tially joining to form a large plateau. This will increase the grad-
ient and force a flow of the water table both north and east. As long
as the uncontaminated water is added at the periphery of the plateau
and the edges are maintained at a higher level than the center, all
of the water in the center will be immobilized. As soon as the addi-
tion of water stops, however, the center portion will eventually move
out perhaps with increased speed due to the increased gradient.

A detailed study of the formation of ground water mounds and their in-
fluence on the travel of the ground water has been started in order
to provide answers to location of optimum disposal points for large
quantities of water, the possible need for transporting some of the
uncontaminated water away from the 200 Areas, and the minimum time of
travel to the river under all foreseeable conditions.

Useful techniques which have been used for the study of ground water
movement in the past include measurements of nitrate or radioactive
isotope concentrations. Techniques under study include the sodium
concentration, addition of tracers, possibly drawdown tests, and nat-
ural tritium concentrations. In the latter case, the water normally
under the area should contain little natural tritium because of the
presumably long time required for the water to reach that point.
Since the water added contains the natural tritium concentration of
the Columbia River, the measurement of the tritium content should
give a reasonable measure of the spread of the water added.

In the meantime, it appears that it is possible to assume a minimum
time of 50 to 100 years even for the most direct route with the best
gradient now available. On this basis, it has been recommended that
cribbing at any location cease when a detectable concentration of any
isotope with a half-life of greater than three years is obtained in
the ground water. This recommendation provides minimum decay by a
factor of 60,000 to 100,000 before the material enters the river.
Little would be gained by increasing the half-life of the isotope in
the ground water to permit smaller factors since the next half-life
of any significant isotope is Sr^{90} which is between 19 and 25 years.
With a decay factor of only 4-5 in the 50 year period, it is not deem-
ed wise to permit quantities of Sr^{90} in the ground water at this time.

5. Audits

In the study of the actual disposal sites used in the past, the work
has been severely hampered by the lack of detailed data on the amounts
and compositions of wastes placed into the crib. Mr. Piper has severe-
ly criticized the disposal practices because of the inability of the
geological studies around the cribs to account for a significant pro-
portion of the isotopes which were estimated as entering the system.[13]
Closer examination of the data indicates that many of the analyses were
not sensitive enough to detect the material so that the upper sensitiv-
ity limits were used in computing the amount to the system or that the
concentrations were measured as entering a settling tank with no good
estimate of what comes out and actually goes to the crib.

It has become a part of the policy of the Radiological Sciences Department

that a careful audit including volumes, salt composition, and isotope
concentration, should be made on all streams to the ground. A sampler
is being designed to permit obtaining of representative samples for
careful analysis, and for laboratory studies on actual streams. This
careful audit becomes more important as permission is granted to crib
more active wastes. It is hoped that by the time Purex is in opera-
tion, all waste streams will be analyzed routinely, and that running
audits of the amount of isotopes actually remaining in the ground will
be available.

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content was obtained from D.W. Rhodes and J.R. McHenry.

JW Healy:swc   RADIOLOGICAL SCIENCES DEPT.
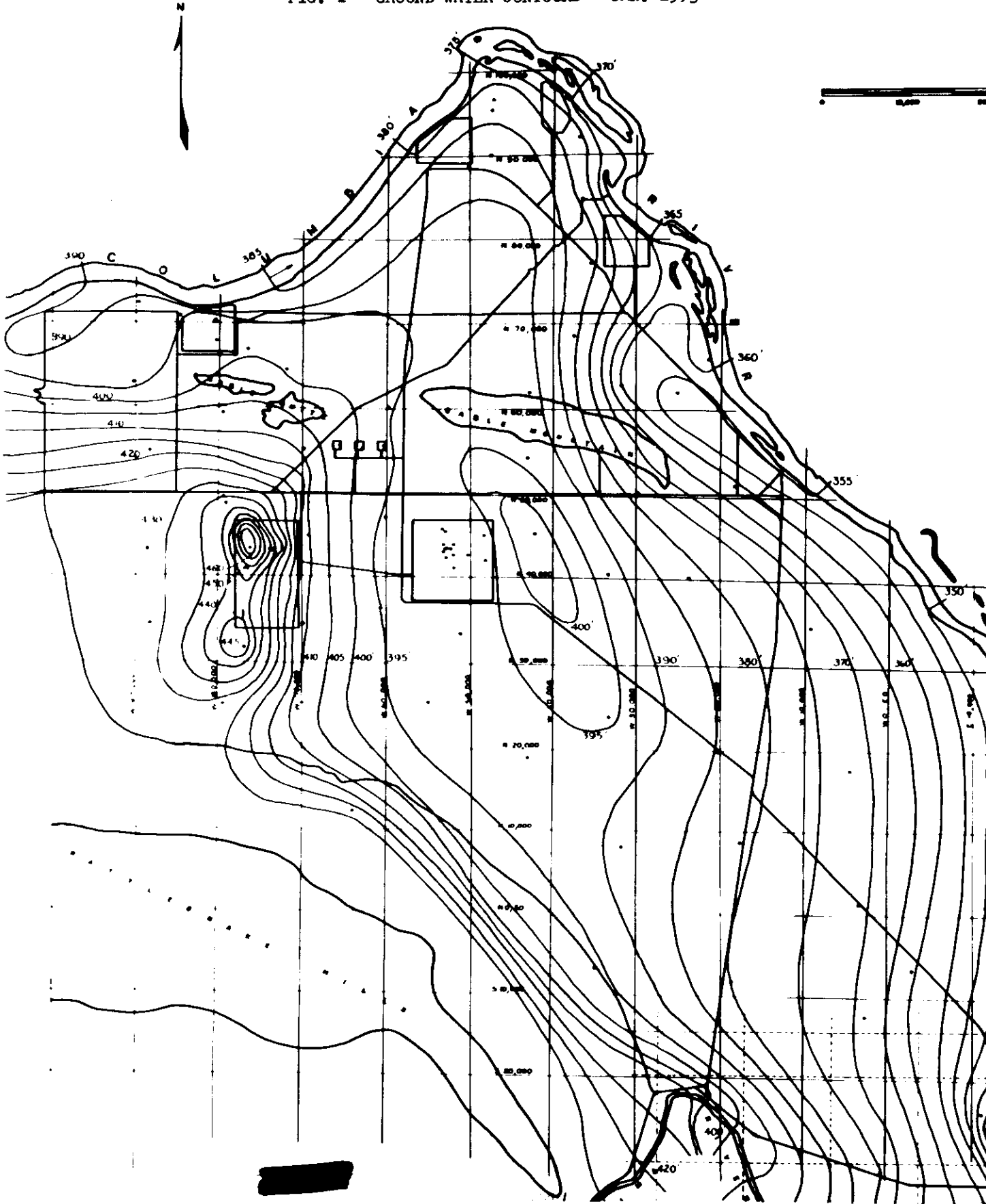
FIG. 1   GROUND WATER CONTOURS - JAN. 1953

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